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PHYSICAL CHEMISTRY.—*Petroleum and the filtering earths.*[1]

P. G. NUTTING, U. S. Geological Survey.

It has been well known to chemists for many years that many clays, soils, etc., are attacked by certain salt solutions, giving off some things and taking up others.[2] In 1907, E. C. Sullivan of the U. S. Geological Survey published a comprehensive review of the subject including his own investigations (*Bull.* 312). Sullivan powdered his mineral, covered it with twice its weight of known salt solution and after several days standing with repeated shakings, analyzed the solution for changes. What happened was simply a base exchange according to the mass law. Copper sulphate solution in contact with kaolin, for example, gives up copper to the kaolin and takes up calcium in its stead. The solution of mineral by the solvent (water) and the adsorption of basic ions from solution by the solid were both found to be relatively small but either may have played an important intermediate rôle in the base exchange.

In the case of earths used in filtering oils, the liquid contains many organic radicals varying widely in basicity. The filtering earths are silicates which are combinations of bases with the weak silicic and aluminosilicic acids. There can be little base exchange proper between the oils and the untreated filtering earths, however, for the exchangeable organic radicals are too weak. Furthermore, in such filtering action as may occur, the reaction products (silico hydrocarbons) are not generally soluble in oil. To get good filtering action the filter

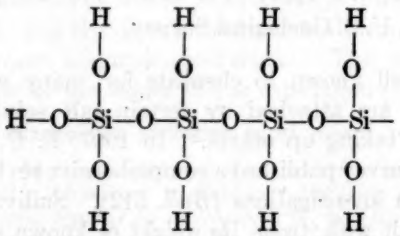
[1] Published by permission of the Director of the U. S. Geological Survey. Received June 20, 1928; revised July 23, 1928.

[2] H. S. THOMPSON. Journ. Roy. Agric. Soc. 11: 68–74. 1850; J. THOMAS WAY. ibid. 11: 313–379. 1850; 13: 123–143. 1852; 15: 491. 1854.

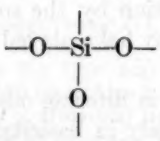
must have its basic radicals removed, leaving open bonds ready to attach to the radicals of the oil to be filtered. In other words the filter is chosen or prepared so as to have terminal hydroxyl (−OH) radicals. Heating drives off water from these, leaving the open bonds essential for filtering. The filtering action is a removal of the less firmly bound alkyl radicals of certain hydrocarbons.

A theory of oil adsorption and filtration essentially as given above was advanced by the writer in 1926 on the basis of known data and some preliminary investigations.[3] Supplementary work since that time has confirmed this theory and supplied many interesting details.

The ideal filter of this class is of course silica gel. In this case a hydrosilicon chain



$(n+1)H_2O \cdot nSiO_2$ or $Si_n(OH)_{2n+2}O_{n-1}$, containing about 23 per cent water is heated nearly to red heat until the water is reduced to about 3 per cent and used before more water can be taken on from the air. The stripped chain will have somewhat the form



the free bonds extending out partly from Si and partly from O atoms. The last of the water is driven off only by heating to very high temperatures (800–1000°C.) for some time. Such treatment destroys filtering power and the power of taking up water, perhaps because the free bonds unite with each other, reducing the silica gel to inactive quartz O=Si=O having but slight affinity for water or for acid or basic radicals.

[3] *Geochemical relations between petroleum, silica and water.* Econ. Geol. May 1926.

Alumina and ferric oxide make almost as good filters as silica if prepared by drying the hydroxide gel. Their action appears to be the same as that of silica gel toward hydrocarbons. Colloidal silicates of the metals (Cu, Zn, Ni, Pb, Mn, etc.) precipitated from salt solutions by sodium silicate, washed and dried, were also found to be good filters. A slight trace of acid remaining on a filter does not affect its action; a trace of alkali destroys it. A large surface area, and free percolation of oil are essential.[4]

This theory of the filtering action of silicates on oils assumes an affinity or surface reaction between the silicates and certain hydrocarbons resulting in a film of organic silicate (or silico hydrocarbon) over the surface. Many hundreds of such compounds are known. Much of the earlier work on them was done by Friedel, Crafts and Ladenburg and a number of them are listed in Beilstein. Much recent work on the structure of the more complex compounds has been done by F. S. Kipping[5] and by Schlenk. A common characteristic of their structure is of interest here.

In a hydrosilicon molecule, Si atoms are usually not directly attached to each other, an oxygen atom intervening. In the hydrocarbons, carbon is bonded directly with carbon without intervening oxygen. In the structure of the organic silicates a mixture of the two habits prevails. Triethylsilicol is considered $(C_2H_5)_3SiOH$; the hydrogen is bonded through O, the ethyl radicals are not. In $C_2H_5Si(OC_2H_5)_3$, three of the ethyls are bonded through O while one is not. A partly stripped (of H_2O) hydrous silicate, as indicated above, has open bonds partly from Si and partly from O atoms, hence might well be selective toward alkyl radicals of various kinds.

This selective action may account for the varied action of different filters toward oils. Many filter to water white, some filter to an amber color, some (slightly alkaline or moist) filter to a canary yellow. Some natural earths are best on mineral oils, others on vegetable oils. Some will even render fish oils tasteless and odorless. Fats and vegetable oils containing oxygen would be expected to require a different filter from petroleum containing little or none. Using very dilute solutions, the writer has prepared silica gels (also those of alumina and

[4] The adsorption of piperidine, nicotine and sixteen other organic compounds from water solution by silica, alumina and ferric oxide has recently been studied by GRETTIE and WILLIAMS. Journ. Am. Chem. Soc. March 1928. They found adsorption by silica gel to be roughly proportional to the basicity of the adsorbed compound. The adsorption of ferric oxide varies widely with mode of preparation.

[5] *Cf. Organic derivatives of silicon* XXXII. Journ. Chem. Soc. 1927: 104.

ferric oxide) so powerful as to break up paraffin hydrocarbons, even paraffin itself and very stable oils of the nujol type.

A spent fullers earth cannot be washed clean by even the most powerful solvents (such as tetrachlorethane) or detergents. Even a boiling sodium carbonate solution fails to lift the film coating the grains. Burning to 800°C. in air simply carbonizes it though some earths may be used four or five times by burning off. Burning in pure oxygen removes most of it. This behavior indicates the formation of some compounds much more stable than any simple hydrocarbon.

A good filter may be flushed with even a heavy clear oil and this afterward driven out by a black crude. The filtering action is not impaired. A filter with all its $-OH$ radicals in place (i.e. with no open bonds) would be expected to filter out only basic radicals stronger than OH. This appears to be substantiated by experiment. An undesiccated filter takes out the black and dark brown near-carbons from petroleum but passes the lighter yellow and orange colored oils.

The matter of color in oils, fats and waxes is a vast subject in itself. Considering briefly only the petroleum hydrocarbons, if we plot as ordinates the series C_nH_{2n-2}, C_nH_{2n}, C_nH_{2n-2}, C_nH_{2n-4}, etc., and as abscissae the number of carbon atoms, the region of colored hydrocarbons lies to the left of the diagonal C_nH_n (acetylene, benzene, retene, etc.) where the hydrogen atoms are fewer than the carbon atoms in the molecule. The higher the carbon ratio, the higher the color. It is the near carbons that are filtered out (retained by the filter) while the colorless hydrocarbons, having more hydrogen than carbon atoms per molecule, are passed by the filter or are very loosely held.

Many of the best filtering earths must be acid treated and washed before being dried for use as filters. These have terminal $-OK$, $-ONa$ or $-O_2Mg$ radicals. Acid treatment converts these to $-OH$ and salts. Washing out the salts and drying produces the open bonds necessary to filtration. Greensand and serpentine make excellent filters after acid treatment. Even natural weathering and leaching is sufficient for some serpentines. Tests with natural clays high and low in alkalies and alkaline earths (selected by C. S. Ross) amply verified the theory just stated.

Still a third method of preparing filters is of scientific interest. A nondescript mixture of clays, such as Texas gumbo, in itself almost without filtering power, may be converted into good filters by dissolving in fused sodium or potassium carbonate. Dissolving the fusion in hot water gives (1) an alkaline solution which is rejected, (2) a floc, chiefly colloidal alumina which is a good filter after washing and drying,

(3) a solid residue, the acid extract of which yields a good filter after precipitation by an alkali, washing and drying and (4) a final residue not soluble in acid, which is a fairly good filter after grinding, washing and drying. It is theoretically possible to split up complex silicates by fused alkalies and to convert the components into filters by acid treatment.

In an oil sand, that oil is considered adsorbed on or combined with silica which will not yield to washing with gasoline. The thickness of the fixed layer is readily determined, for it may be completely removed from a non porous sand with chromic acid. Using a very pure and uniform silica sand (Tensleep, Oregon Basin, Wyoming, 3850 feet) a thickness of 0.75μ was found, which is 15 to 20 times the thickness of the water film adsorbed by the same silica at ordinary room humidities. The clean sand, soaked in an asphalt base oil over night, acquired a new film of very nearly the same thickness. This method may be of assistance in the analysis of heavy oils and asphalts as silica is a definite weak acid.

Some geological and practical applications of the principles just advanced are of interest. The question is often raised, how could petroleum have replaced water solutions in oil sands when tests show that water drives out oil and oil can not be made (by pressure) to drive out water except from the larger pores. The answer is simple. If the petroleum contains heavy unsaturated hydrocarbons, the whole or some part of which is stronger than OH, these first coat the sand grains which then in effect become tar grains and absorb oil in preference to water.

In the soda process for petroleum recovery, developed by the writer in the laboratory and now being used in the field, a soda solution was found to be very effective in freeing the sand from petroleum. With tar coated sand grains the action of the soda is much slower as the diffusion of the soda through the adsorbed film is necessarily very slow. Nevertheless in the end very clean removals are obtained. Much effort has been spent on the measurement of the retention of oil by sand ignoring the enormous effect of but a few parts per million of tarry constituents in the oil.

Trinidad asphalt contains uniformly 35.5 per cent of silicate matter in the form of clay and fine earth and 10 per cent water of hydration. If this mineral matter is partly a filtering earth as defined above, then it is not difficult to account for the formation by the upward percolation of an asphalt base petroleum. With the clay wet, only the heavier tars would be strongly adsorbed, carrying the clay with it in a definite proportion.

In summary then we may say that filters filter because of open O and Si bonds. These are produced by removal of H_2O from terminal OH radicals. They act by attacking certain alkyl or weakly basic radicals of the hydrocarbons. The result may be mere adhesion but is in many cases a surface reaction in which a film of organic silicate is formed over the surface of the filter grains. Many of the organic silicates thus formed are insoluble in any single known solvent.

Clays of the kaolin type (kaolinite, halloysite, anauxite, $H_4Al_2Si_2O_9$) do not filter because they contain no hydroxyl water that can be driven off leaving open bonds.

Clays of the bentonite type make only poor filters even after acid treatment because they contain only a little alkali replaceable by hydroxyl.

Good filters, either artificial or natural, are of two types; (1) those well supplied with hydroxyl water removable by moderate heating and (2) those having originally had terminal alkali radicals subsequently converted to hydroxyl by acid treatment.

The selective action of filters is readily accounted for by the varying activity of open bonds toward organic radicals retained by bonds of varying strength.

The penetration of petroleum into water-soaked sand and the possible formation of Trinidad asphalt are discussed.

GEOLOGY.—*The stratigraphy and age of the Pleistocene deposits in Florida from which human bones have been reported.*[1] C. WYTHE COOKE, U. S. Geological Survey.

Human remains in close association with extinct vertebrates of Pleistocene aspect have been found at three places along a hundred-mile stretch of the east coast of Florida. In 1916 E. H. Sellards announced the first discovery at Vero, a town 65 or 70 miles north of West Palm Beach. In 1924 F. B. Loomis found artifacts mingled with a similar extinct fauna at Melbourne, 30 miles north of Vero, and later Gidley and Loomis found human bones there apparently in the same bed with the extinct fossils. Early in 1928 Gidley made additional finds at Melbourne and discovered another locality at New Smyrna, a town 15 miles south of Daytona and 100 miles north of Vero. In

[1] Read before the Geological Society of Washington, May 9, 1928. Published by permission of the Director of the U. S. Geological Survey. Received May 18, 1928.

a paper recently presented before the National Academy of Sciences, Gidley reaffirmed his previous conclusions that man and extinct animals were contemporaneous. In view of these repeated discoveries of fossil man in Florida, it seems desirable to summarize again the stratigraphy of the region and to attempt to determine the age of the deposits in which the human bones are reported to have been found. I shall assume throughout this paper that the human remains really occurred in and formed part of the bed to which they have been attributed by their discoverers, although it should be distinctly understood that the burden of proof of this very important fact lies directly upon those who have found the bones. It is to be hoped that Doctor Gidley will soon publish an account of his latest observations and discoveries. References to the literature are listed in the footnote.[2]

The stratigraphic succession at Vero, Melbourne, and New Smyrna is essentially the same. The bed rock at all three localities is a marl composed of sea shells and sand and known as the Anastasia formation. Most previous writers have referred to it as the Number 1 bed. This formation underlies the East Coast from St. Augustine to Palm Beach County. It is obviously a littoral marine formation. The shells in it are nearly all of living species and give no clue as to what part of the Pleistocene it belongs.

The Number 1 bed is overlain unconformably by the Number 2 bed, or, as I prefer to call it, the bone bed. The bone bed consists chiefly of fine sand. At Melbourne the sand varies from white to light brown and contains a few local irregular lenses of marine shells that appear

[2] E. H. SELLARDS. *Literature relating to human remains and artifacts at Vero, Fla.* Am. Journ. Sci. (4) **47**: 358–360. 1919; Florida Geol. Surv. 12th Ann. Rept., pp. 1–4. 1919 (cites 24 titles). H. F. WICKHAM. *Fossil beetles from Vero, Florida.* Am. Journ. Sci. (4) **47**: 355–357. 1919; Florida Geol. Surv. 12th Ann. Rept., pp. 5–7. 1919. T. C. CHAMBERLIN. *Investigation versus propagandism.* Journ. Geol. **27**: 305–338. 1919. F. B. LOOMIS. *Artifacts associated with the remains of a Columbian elephant at Melbourne, Florida.* Am. Journ. Sci., (5) **8**: 503–508. 1924. W. H. HOLMES. *The antiquity phantom in American archeology.* Science, (N.S.) **62**: 256–258. 1925. F. B. LOOMIS. *Early man in Florida.* Nat. Hist. **26**: 260–262. 1926. J. W. GIDLEY. *Investigations of evidences of early man at Melbourne and Vero, Florida.* Smiths. Misc. Coll. **78**: 23–26. 1926. O. P. HAY. *On the geological age of Pleistocene vertebrates found at Vero and Melbourne, Florida.* This JOURNAL **16**: 387–392. 1926. J. W. GIDLEY and F. B. LOOMIS. *Fossil man in Florida.* Am. Journ. Sci. (5) **12**: 254–264. 1926. J. W. GIDLEY. *Fossil man in Florida* (Abstract): Bull. Geol. Soc. Am. **37**: 239–240. 1926. C. WYTHE COOKE. *Fossil man and Pleistocene vertebrates in Florida.* Am. Journ. Sci. (5) **12**: 441–452. 1926. O. P. HAY. *A review of recent reports on investigations made in Florida on Pleistocene geology and paleontology.* This JOURNAL **17**: 277–283. 1927. O. P. HAY. *Again on Pleistocene man at Vero, Florida.* This JOURNAL **18**: 233–241. 1928.

to have been washed or blown in from the sea at a time when the shore stood close by. Where shell lenses are absent the bone bed appears massive or is streaked horizontally by dark carbonaceous sand. The bone bed ranges in thickness from a thin film up to perhaps 10 feet. No muck, peat, or leaves have been found in it at Melbourne, although the bed that has been correlated with it at Vero contains local accumulations of vegetable matter in old drainage channels.

It is possible that the bed at Vero called "Number 2" by Sellards is younger than the Number 2 bed at Melbourne, for "within the stratum, filling holes or channels in the underlying deposit, are found local accumulations of muck, including often wood, sticks, acorns, snail shells, and vertebrate fossils. As a rule the sand near the base of this stratum is light-colored and distinctly cross-bedded."[3] This description fits the stream deposits much better than it fits the bone bed which I saw in a freshly-dug trench at Vero in 1926. Sellards' original excavations are filled or overgrown.

I have called the Number 2 bed the bone bed because it contains great numbers of bones. Many of the bones represent species that are now extinct. Among them are camels, horses, mastodons, elephants, tigers, and armadillos. Man lived among them, for Doctor Gidley has found a skull, crushed as if trampled by an angry elephant. These extinct animals, according to Dr. O. P. Hay, comprise a fauna of very early Pleistocene aspect that is usually referred to the Aftonian or first interglacial stage. The association of human remains with this fauna is of the utmost significance, for it proves either that man has been in America since the early Pleistocene or that the so-called Aftonian fauna did not perish at the close of the first interglacial stage.

A few words as to the manner of accumulation of the bone bed are appropriate at this point. Sea level had been depressed and the newly-emerged shell-covered bottom stood a few feet above tide. Back of the sandy beach ridge lay poorly drained, grassy meadows, the pastures of countless herds, upon which wind-blown sand gradually accumulated and buried the skeletons of animals that died there. It is quite likely that the meadows were occasionally flooded by torrential rains, by back water from lagoons, or by salt water blown ashore by gales, just as the plains around Moorehaven were overwhelmed by Lake Okeechobee during the recent hurricane. The presence of a few lenses of marine shells in the bone bed, a continental deposit, may thus be accounted for. Some of the animals whose bones are found

[3] E. H. SELLARDS. Journ. Geol. 25: 8. 1917.

in the Number 2 bed may have been drowned in floods; more, doubtless, died the natural deaths of the wilderness.

Sometime during this episode man appeared on the scene. Some of his bones and implements were buried by the drifting sand and became part of the bone bed. Others, remaining longer on the surface, were eventually covered by the stream and bog deposits that I shall now describe.

Lying upon the bone bed and effectually sealing it from the accidental intrusion of objects from above, are patches of fresh-water deposits that have been called the "Number 3 beds." At Vero and Melbourne the "Number 3 beds" are swamp and stream deposits that consist of muck and partly decomposed roots, bark, and leaves, interstratified with yellowish sand. Fresh-water mussel shells are abundant in the stream deposit at Melbourne. At New Smyrna, according to Doctor Gidley, there is no clearly-defined stream channel, but the bone bed, Number 2, is covered by a peaty bog. It is very unlikely that human bodies could have been buried in the bone bed by sorrowing relatives without leaving easily discoverable traces of the hole in the peat bed through which the remains of the late lamented were interred. Neither Doctor Sellards nor Doctor Gidley has detected any evidence of such intrusion. The human bones must have been there before the peat bed accumulated.

The Number 3 beds are obviously recent. The accumulation probably began immediately after a rise of sea level that drowned the valleys of Van Valkenburg Creek at Vero, Crane Creek at Melbourne, and St. Johns River at Jacksonville on the East Coast and produced Charlotte Harbor and Tampa Bay on the West Coast. The fresh-water deposits continued to accumulate until the process was interrupted by the cutting of drainage canals a few years ago. How many years elapsed during this interval I am not prepared to say. Estimates based upon the thickness of the Number 3 beds (about 5 feet at Melbourne) and the rate of accumulation of various kinds of fresh-water deposits might be attempted but there are so many variable factors that such estimates would not be very reliable.

The topography of the region throws some light on the probable ages of the beds. The fossil-bearing localities near Vero, Melbourne, and New Smyrna are all on a nearly level plain that extends inland a distance of 20 or 25 miles and stands chiefly between the altitudes of 20 and 30 feet above sea level. They lie back of a low sandy ridge whose crest is less than 40 feet above sea level in the vicinity of Melbourne but which is more conspicuous and perhaps somewhat higher

near Vero. This ridge probably is a former beach ridge that marks a temporary position of the shore during emergence of the sea bottom.

The plain that I have just described is the lowest well-defined member of a series of terrace plains that front the Atlantic Ocean from Delaware Bay to the Straits of Florida. In Georgia it is called the Satilla terrace. It probably corresponds to the Chowan terrace of North Carolina and to the Talbot terrace of Maryland. It obviously is an emerged sea bottom, for it is floored with sea shells. Before its emergence the shore line stood at an altitude of approximately 60 feet above the present sea level. Farther north in Florida and in Georgia, still older shore lines can be traced on topographic maps at altitudes 100 and 160 feet above sea level and there are even higher terraces that also may be marine.[4]

These ancient shore lines and the flight of step-like terraces that lie between them are supposed to represent different stages of the Pleistocene epoch. The highest terrace, being presumably the first to emerge, is the oldest; and the lowest, being most recently under water, is the youngest.[5] The Satilla terrace with the 60-foot shore line does not correspond to the very latest stage of the Pleistocene, for, although the Satilla is the lowest *well-defined* terrace, there appears to be a still lower and younger terrace with a shore line 20 or 25 feet above sea level and bordered by the somewhat higher beach ridge mentioned above. Stephenson has recognized such a low terrace in North Carolina and named it the Pamlico. Wentworth has detected it also in Virginia.

Doctor Hay has recently published the statement that none of the terraces, not even the one on which the fossil bones are found, is marine because they do not contain any marine fossils.[6] This statement seems surprising in view of the fact, well known to Doctor Hay, that the Anastasia formation or Number 1 bed is composed chiefly of sea shells. He is evidently confusing the deposits on the terrace with the terrace

[4] For a description of the terraces in Georgia see C. WYTHE COOKE. *Physical geography of Georgia.* Georgia Geol. Survey Bull. **42**: 21–35. 1925.

[5] Melting of the existing polar ice caps would raise the level of the sea to a height comparable to that of the highest shore line definitely recognized in Florida. If the land has remained stationary and the elevated shore lines correspond to inundations caused by melted ice, then deglaciation during the interglacial stages of the Pleistocene was more complete than now, and the height of each shore line is a measure of the extent of deglaciation during the corresponding period. If, as is commonly assumed, the highest terrace is the oldest and the lower terraces are progressively younger, the highest terrace should have been under water during the first interglacial stage or before the first glaciation and the lowest terrace during the last interglacial stage. During the intervening glacial stages sea level may have been depressed below its present position.

[6] O. P. HAY. This JOURNAL **18**: 236. 1928.

itself—the table cover with the table. A marine terrace is an emerged sea bottom. The marine terrace at Vero and Melbourne, strictly speaking, is the surface of the Number 1 bed, which was the old sea floor. The Number 2 and Number 3 beds, which are nonmarine, are *on* the terrace. They correspond to the table cover.

It is true, as Doctor Hay contends, that no sea shells have been found on the higher terraces, but that fact does not outweigh other evidences of their marine origin. The marine deposits on the higher terraces consist only of a thin veneer of loose sand. What chance would sea shells embedded in porous sand have of resisting through many centuries the corrosive action of organic acids in the soil? Great caves have been dissolved in solid limestone by rain water in no longer time than the higher terraces have been above the sea.

What agency but the sea could distribute a cover of fine white sand over a plain several thousand square miles in extent on the divide between the Atlantic Ocean and the Gulf of Mexico? What agency but the sea could build on the outer edge of this plain a sand bar 130 miles long and 2 to 4 miles wide extending parallel to the present coast and 40 feet higher on the seaward side than on the landward side? I refer to the Okefenokee terrace and Trail Ridge.

Let us now trace the principal events in the history of Florida during the Pleistocene epoch. Early in Pleistocene time, possibly during the first interglacial stage, much of the peninsula of Florida was submerged beneath the sea and the shore line stood at the 160-foot level. A long sand bar, now Trail Ridge, was built northward into Georgia from an island and shut off a sound similar to the present Pamlico Sound of North Carolina. Later the sea withdrew to the 100-foot level, Trail Ridge became the sea shore, and the sound was converted into Okefenokee Swamp. Once more the sea lowered, and came to rest at an altitude of only 60 feet above its present level. The shore line then stood at most places west of the present course of St. Johns River. The sites of Vero, Melbourne, and New Smyrna were still under water.

As a result of the next oscillation the sea halted about 20 feet above its present level. Shell-covered barrier beaches separated from the mainland by lagoons appeared above the waves, were covered with vegetation, and became the home of a great variety of land animals and turtles. Sand blown from the beach gradually silted up the lagoons and accumulated in hollows in the lee of the beach ridge. Man at last appeared. This was the period during which the bone beds at Vero, Melbourne and New Smyrna accumulated.

The next event appears to have been a further emergence of perhaps 60 feet. The sea retreated to a position about 40 feet below its present level, the lagoons were emptied, and streams began vigorously to erode their channels.

Erosion had not progressed very far before it was checked by a submergence that drowned the lower courses of the streams and brought the sea to its present level. This event may logically be considered the beginning of the Recent epoch.

The more important facts of history and stratigraphy can be summarized as follows: Bones of prehistoric animals of early Pleistocene aspect and human bones were buried by sand blown from the neighboring seashore and deposited on the Satilla terrace, a newly-emerged sea bottom. Further emergence of 60 feet removed the shore to such a distance that deposition of sand ceased and streams began to trench the deposits already formed. Partial submergence then choked the lower courses of the streams and made them boggy.

Deposits of three ages have been distinguished: First, a Pleistocene marine shell marl, known as Number 1 bed. Second, a Pleistocene bone bed with human remains, called Number 2 bed. Third, Recent stream and bog deposits called Number 3 beds.

As to the age of the bone bed: In view of the long succession of Pleistocene events that preceded the emergence of the Satilla terrace on which it rests, it seems scarcely possible that the bone bed can be as ancient as the Aftonian or first interglacial. On the other hand, it can hardly be the very latest Pleistocene, for we have to allow time at the close of the Pleistocene for an uplift and a depression. If the emergence that followed the accumulation of the bone bed was contemporaneous with the Wisconsin glaciation, the bone bed might well have been formed during the Peorian or fourth interglacial stage.

The purpose of this paper has been simply to describe the stratigraphy of the region in which human remains have been found and to endeavor to ascertain the ages of the various beds. I have given no details regarding the manner of occurrence of the human bones and artifacts because I have not been so fortunate as to find any human remains myself nor to be present when they were discovered by others. I have assumed that the association of human remains with the Pleistocene fauna as reported by Dr. Gidley is so well authenticated that there seems little reason to doubt that man actually lived in Florida during the latter part of the Pleistocene.

Is it after all so surprising to find him there? Need we assume for

man a more rapid evolution than that of other almost equally complex mammals? Nearly all of the existing species of mammals are survivals from the Pleistocene. The essential difference between the Pleistocene and the Recent faunas is one of quantity rather than kind. Many species became extinct during or at the close of the Pleistocene, but few new species or subspecies originated during that time. One would therefore expect to find that the Pleistocene progenitors of the modern man are indistinguishable from ourselves. Other contemporary races of primitive man that are now extinct represent collateral lines and are not our ancestors.

The presence of man in America, assuming that he originated in the old world, is no more difficult to explain than the presence here during by-gone ages of camels, horses, elephants, rhinoceroses, and other genera that are now restricted to Africa or Asia.

PALEONTOLOGY.—*Characteristic mammals of the Early Pleistocene.*[1] OLIVER P. HAY, Washington, D. C.

For the writer the Pleistocene is the equivalent of the Ice Age. We may say that it began when the first ice sheet, the Nebraskan, had pushed southward to about the 55th degree of latitude. It had perhaps even then begun to disturb the ancient drainage systems. It ended when the Wisconsin glacier had retreated to the same latitude, opening up the main river systems of our times. Within that interval there had occurred momentous changes in the physiography of our continent, in its climates, and in its highest forms of animal life.

I wish to discuss especially the composition of the mammalian life of the Pleistocene and some of the changes which it underwent.

The kinds of mammals that existed on our continent during the late Pliocene are not sufficiently well known. We know, however, that there were present a few edentates, various carnivores of dog-like and cat-like forms, mastodons, tapirs, horses (possibly not yet *Equus*), peccaries, camels, and antelope-like hoofed animals. After the close of the Pliocene no doubt some of those mammals, somewhat modified, lived on into the Pleistocene. We are sure that a few of the edentates did so; also some of the tapirs, peccaries, camels, and some of the early horses.

About the beginning of the Pleistocene a passage was opened up

[1] Received July 20, 1928.

between Asia and North America. Over this many kinds of Old World mammals entered our continent. Elephants of perhaps several species, new mastodons, bisons, musk-oxen, deer, moose, wolves, tigers, possibly horses and camels, descendants of former migrants from this country into Asia, pressed in and spread over the land. About the same time, perhaps a little earlier, a highway was established between South America and North America and our land was invaded by the strange fauna of the southern continent. The most conspicuous of these animals belonged to the order of Edentates, and consisted of huge ground-sloths, armadillos, and glyptodons. More than a dozen genera of these edentates have been described; and they varied in size from that of the existing Texan armadillo to that of an elephant. Our early Pleistocene mammalian fauna was, therefore, a product of three continents and it was a fauna probably more abundant in numbers and more diverse in species than any other known.

About the genera and species of mammals which existed in our country during the first glacial stage we know little or nothing, I mean little that is derived from actually discovered remains. We can only judge as to their general nature from those which preceded them and those which followed them.

I shall now attempt to show that certain important elements of the mammals I have mentioned existed in our country in what is believed to be the first interglacial stage.

Along the Missouri River, from the northwestern corner of the State of Missouri to the mouth of Sioux River and along this to the northwestern corner of Iowa, at many localities, have been discovered deposits, gravels and sands, intercalated between the first (Nebraskan) and the second (Kansan) drifts. These gravels and sands are known as Aftonian deposits. In these have been discovered a considerable number of fossil mammals. In one gravel pit near the town of Missouri Valley, 18 species have been reported. Of these, 90 percent are extinct. They represent eight families and twelve genera. There are two species of ground-sloths (*Megalonyx* and *Mylodon*), three species of elephants, one or two of mastodons, four species of horses, at least one species of camel, a moose, a bison, a musk-ox, a goat, the existing bear, and a beaver.

In this one pit, therefore, have been found representatives of 8 families of mammals, *Megatheriidae* (ground-sloths), *Castoridae* (beavers), *Elephantidae* (elephants), *Equidae* (horses), *Camelidae* (camels), *Cervidae* (deer), *Bovidae* (oxen), and *Ursidae* (bears).

Near Akron, Plymouth County, were found two teeth of *Stegomastodon mirificus* in Aftonian deposits. In a deposit of the same stage, at Mapleton, Harrison County, was found a fine tooth of *Elephas imperator*. At Afton, Iowa, were collected foot bones and a tooth of *Hipparion*. At Rockport in northwestern Missouri, in the Aftonian sands and gravels, were found a foot-bone of a horse, a tooth of a camel, and a molar tooth of *Hipparion*.

Near the present post-town of Peters, Sheridan County, in northwestern Nebraska, near Niobrara River, in a deposit of sand lying between 50 and 100 feet above the little tributary of the river, were collected many years ago about 20 species of mammals. Of these at least 70 percent are extinct. The fossils represented 13 families and 16 genera. These include two genera of ground-sloths, two dogs, an extinct genus of bears (*Arctotherium*), a prairie dog and a musk-rat, a field mouse, two elephants, one of them *Elephas imperator*, an extinct genus of peccaries, three species of camels, two species of prong-horn antelopes, one possibly the existing species, the other the extinct *Capromeryx furcifer*. The bed of sand containing these fossils is about 12 feet thick and overlies late Tertiary deposits. Since the bed was laid down, Niobrara River has cut its valley nearly 100 feet deeper.

I ask you now to consider Pleistocene fossil mammals which have been found in the canyon of Tula Creek, Briscoe and Swisher Counties, Texas. During probably the early part of the Pleistocene, by a quickening of a stream, approximately 100 feet of deposits were removed from the Miocene. Then came a change either in a reduced slope of the country or in a smaller amount of water or both, and deposition recommenced. There was laid down first about 30 feet of coarse sand, over this 15 feet of bluish clay, then again course sand, and finally 25 feet of fine white sand. This variation in the materials implies changes in climate and of elevation, and consequently this deposition of 90 feet of sand and clay required a long time. Then occurred a more momentous change in affairs. The region must have been considerably elevated as also the country west of it, for extensive cutting began. This continued until a broad valley had been eroded through all of that 90 feet of Pleistocene materials, then through the Miocene and down into the Triassic clay below. That canyon so cut is, less than 10 miles farther down, 400 or 500 feet deep. We can not doubt that those deposits belong to an early stage of the Pleistocene.

Now in the first coarse sand laid down and in the last stratum of fine sand have been found numerous specimens of Pleistocene mammals.

About 20 species have been collected. These include a ground-sloth (*Mylodon*), a glyptodon, two elephants, one being *Elephas imperator*, from four to six species of horses, a peccary, four species of camels and two species of dogs. All of the species collected are now extinct.

I ask you now to consider a fourth important locality, one whose geology certifies to the age of the fossils discovered.

Frederick, Tillman County, is in southwestern Oklahoma, about 12 miles north of Red River. From the town there runs northward for about ten miles a prominent ridge, and this near the town stands about 100 feet above the adjacent country. In one side of this ridge a sand and gravel pit has been opened and is being extensively operated. The ridge is found to be a filled-up and abandoned river bed, probably that of the ancient North Fork of Red River. The filling consists of, first, a stratum a foot or two thick, of broken rocks and gravel cemented by carbonate of lime, forming a mass of considerable hardness. Above this is a rather hard sandstone of about the same thickness. This is overlain by some ten to fifteen feet of compact sand and gravel; while above all comes about three feet of a red clay. The whole rests on a red clay of Permian age. At present the North Fork runs about ten miles west of Frederick and at a level of 200 or more feet lower down.

Now principally in the lowest cemented layer, but to some extent in the compact sand, have been discovered numerous fossil bones of mammals. Since they were buried there the river valley was filled and choked up, the river diverted into other channels, and the immediate region has been eroded away more than 100 feet, while further west probably more than 200 feet. It will be understood at once that a very long time must have been required to accomplish that work. Inasmuch as the animals found there are in general the same as those found in the three other localities mentioned it is concluded that the time of their burial was during the first interglacial stage. The fossils collected consist of a megalonyx, a mylodon, a mastodon, a glyptodon, three or four horses, a large tapir, a large and a small camel, a peccary, an elephant more primitive than *E. imperator*, two other elephants, a mastodon which appears to belong to the long-jawed genus *Gomphotherium*. All of the species are extinct.

Collecting together then the animals found in the western Iowa localities (1), that on Niobrara River (2), that in Tula Canyon (3), Texas, and that at Frederick (4), Oklahoma, we have the following list:

Megalonyx jeffersonii 1, 2, 4
Mylodon harlani 1, 2, 3, 4
Glyptodon petaliferus 3, 4
Equus complicatus 1, 3, 4
E. niobrarensis 1, 2
E. laurentius 1
E. scotti 3
E. excelsus 1, 2, 3
E. calobatus 3
E. tau ? 3
E. semiplicatus 3
Tapirus haysii 4
Platygonus compressus 3
P. sp. indet. 2, 4
Camelops huerfanensis ? 3
C. vitakerianus 2
C. macrocephalus 3
C. kansanus 2
C. hesternus 3
C. niobrarensis 4
Lama sp. nov. 4
Camelus americanus 2
Eschatius conidens 3
Alces shimeki 1
Capromeryx furcifer 2
Antilocapra americana ? 2
Symbos cavifrons 1
Aftonius calvini 1
Bison sp. indet. 1
Elephas haroldcooki 4
E. imperator 1, 2, 3
E. columbi 1, 2, 3, 4
E. boreus 1, 4
E. primigenius ? 4
Mammut americanum 1
M. progenium 1
Stegomastodon mirificus 1
Gomphotherium sp. nov. 4
Castor canadensis 1
Castoroides ohioensis ? 2
Microtus sp. indet. 2
Ondatra nebrascensis 2
Thomomys sp. indet. 2
Cynomys ludovicianus 2
Lepus sp. 4
Ursus americanus 1
Arctotherium sp. indet. 2
Ænocyon dirus 3
Canis occidentalis ? 2
C. texanus 3
C. latrans 2
Smilodon nebrascensis 2

In this list there are included more than 50 species which appear to have lived during the first interglacial stage. I do not see how this conclusion can be escaped. Most of those of the list represent mammals which are to be found in deposits all over the Great Plains into Texas and Mexico and many of them are found in Florida and South Carolina. When white men discovered this continent the great majority (80 percent) of the animals here listed no longer existed.

Now the question arises: Did all of these animals that are now extinct, and many others not here mentioned, live on until near or into the Recent epoch and then suddenly disappear, or did the extinctions occur at various times during the first interglacial stage and since that time?

What can we learn about the longevity of mammalian genera and species on comparing them with genera and species of mollusks? Several genera of mollusks have persisted ever since the Jurassic; many more from the Cretaceous. The oldest living genus of mammals is, I think, *Didelphis*, the opossum, and this comes down to us from only the Eocene. Following Matthew's list[2] we find that of

[2] Bull. U. S. Geol. Surv. No. 361.

90 Miocene genera only 11 now exist (12 percent); of species none. With few exceptions the Miocene species do not continue from one formation to the next. In a geological sense, therefore, mammalian genera and species are short-lived. This being true I hold that it is improbable that all of the species of the list presented lived until the close of the Pleistocene. In that first interglacial stage there were thrown together three incongruous faunas, and it was inevitable that in the struggle for existence some would succumb. This would have happened even if the physical environment were favorable, but with the changes resulting from three or four glacial stages and two or three interglacial stages extinctions would be multiplied.

The fact that the collections from the older Pleistocene deposits show a much higher percentage of extinct forms than from known later ones is evidence that the extinctions occurred at all times. Had all the first interglacial species lived until the end of the Pleistocene, collections from all of the stages would show approximately the same percentage of extinct species.

The history of the Pleistocene animals of Europe shows that the older deposits contain a higher proportion of non-existing species, the majority or all of the earliest deposits being extinct.

Out of the list which has been presented I select the following species as being a part of those of which we find no traces after the close of the first interglacial stage, or at least, after the Kansan glacial stage.

Glyptodon petaliferus
Equus niobrarensis
E. laurentius
E. excelsus
E. semiplicatus
E. calobatus
Camelops huerfanensis
C. hesternus
C. niobrarensis
C. vitakerianus
C. macrocephalus
C. kansanus
Eschatius conidens
Camelus americanus
Elephas haroldcooki
E. imperator
Smilodon nebrascensis

To these I add the following because they have been found associated with those of the number just given and are evidently of the same geological age.

Smilodon floridanus
Neochœrus pinckneyi
Stegomastodon mirificus
Megatherium mirabile
Chlamytherium septentrionale

Here are listed 22 species of large and important animals of which the writer affirms that they have not been found at any locality the

geology of which can be determined as being later than the first interglacial or the second glacial stages. In support of my position I present the following five sources of evidence.

1. Remains of none of these species have been found in deposits overlying either the Kansan, the Illinoian, or the Wisconsin drift sheets. Many other extinct species have been found in such deposits, ground-sloths, a horse or two, the giant beaver, various species of peccaries, elephants and mastodons. Species of the last list furnished may be found around the borders of these drift sheets; and it is for those who believe in their late existence to explain why these animals did not venture to cross the moraines. The mastodons and the elephants, *Elephas boreus* and *E. columbi*, which more than once were driven from the glaciated regions returned to their old pastures. The camels which inhabited western Iowa did not return.

2. In a fissure in northwestern Arkansas Barnum Brown collected about 50 species of mammals. These appear to have lived about the time of the Illinoian drift stage. Not one of the species of the last list presented was found there.

3. A considerable number of collections of fossil mammals have been made in the Appalachian Mountains from Lookout Mountain, in southern Tennessee, to Frankstown, Pennsylvania. At Lookout Mountain have been found a small horse, a ground-sloth and a tapir. From Winterburg, in northeastern Tennessee, there have been described 18 species of mammals, including 2 horses, a tapir, 3 deer, and *Elephas boreus*. In Wythe County, Virginia, Cope long ago collected 19 species of Pleistocene mammals, among them a megalonyx, a tapir, a horse, a peccary, a bison, and an extinct bear. From a cave in western Maryland the writer has recorded 24 species of mammals, including 2 horses, 6 peccaries, 2 deer, an elephant, probably *Elephas columbi*, and one species of saber-tooth tiger. From a fissure in limestone, near Corriganville, Maryland, Gidley collected 40 or more species of mammals, among them an extinct bear, a mastodon, a horse, a tapir, 5 species of peccaries and many small species of rodents.

Near Frankstown, Pennsylvania, 10 miles south of Altoona, in a limestone cave, were collected by the Carnegie Museum, Pittsburgh, a considerable number of fragmentary fossils, a megalonyx, a tapir, a peccary, a bison, a mastodon, 2 bears, the dog *Ænocyon dirus*, a musk-ox, and a horse.

Now all of these collections made in the Appalachian ranges appear to belong somewhere about the middle of the Pleistocene, in possibly

the Yarmouth or the Sangamon interglacial stages. In none of them are there any of the forms which I regard as peculiar to the first interglacial. If these species were then living it is hardly comprehensible that they did not occupy that region. At Nashville a large camel, perhaps a species of *Camelops*, has been found, accompanied by 2 species of horses, a *Mylodon*, and a deer; but these fossils occurred in stratified deposits at a depth of 30 feet and on a level with low water in the river; so that there is no reason for believing that they are not old. The occurrence of these at that locality shows that these animals were once able to visit that region.

4. The Mississippi embayment extends from Cairo to the Gulf. On each side of the river is a deposit which has been called the Port Hudson. In this deposit at various localities have been found important fossils.

From a deposit of blue clay believed to belong to this Port Hudson, and overlain by some 50 or more feet of a later deposit, situated near Natchez, Mississippi, or possibly partly collected from the later deposit, have been described the following seventeen species of mammals:

Megalonyx jeffersonii
M. dissimilis
Mylodon harlani
Ereptodon priscus
Equus complicatus
E. leidyi
Tapirus haysii
T. terrestris
Odocoileus virginianus
Symbos cavifrons
Bison latifrons ?
Mammut americanum
Elephas columbi ?
Castoroides ohioensis
Ursus americanus
U. amplidens
Felis atrox

In Louisiana, in this Port Hudson, have been discovered at various localities mastodons, elephants, mylodons, megalonyx, horses, and tapirs. These genera and species are such as lived during the middle portion of the Pleistocene. We have, however, no account of there having been found, either in Louisiana, or any of the states bordering on the Mississippi as far north as Cairo, any camels or any of the other extinct animals the writer named as characterizing the first interglacial deposits. They abound, however, in Texas, and again in Florida. On account of the mild climate we might expect to find in this embayment *Megatherium*, *Glyptodon*, *Elephas imperator*, various camels, capabaras and saber-tooth tigers. If they ever left their bones and teeth in this Mississippi River region the remains appear to have been swept away by the floods of that great stream or to have been buried out of sight in its later deposits.

5. There is another important deposit in which we might expect

to find descendants of the early Pleistocene animals named, if there were any such descendants. This deposit, laid down during probably two distinct stages of the early middle and late middle Pleistocene, is known as the loess, a wind-laid element. It is found as a deep deposit along the Mississippi River from Natchez to northern Wisconsin and along the Missouri River to western Iowa and beyond. In places it abounds in land shells, but it has afforded here and there a few vertebrate fossils. In a deposit of loess at Alton, Illinois, the following list of 15 species of mammals were discovered many years ago.

Megalonyx jeffersonii
Equus sp. indet.
Platygonus cumberlandensis ?
Sangamona fugitiva
Cervalces roosevelti
Rangifer muscatinensis ?
Taurotragus americanus
Symbos cavifrons
Bison sp. indet.
Mammut americanum
Castor canadensis
Marmota monax
Castoroides ohioensis
Geomys bursarius
Ursus americanus

It will be observed that at least two-thirds of these fossils are of extinct species. This suggests that their time of existence was well back in the Pleistocene. Dr. Leighton, who studied[3] the situation, was unable to determine with exactness the ages of the two beds of loess which overlay the bones. The lowest bed may be as old as the late Illinoian or early Sangamon stages. At any rate, none of the species regarded by the writer as belonging to the early Pleistocene are present in the collection.

The writer maintains therefore that he has demonstrated that the list of 50 species of mammals given on page 425 lived during an early stage of the Pleistocene, probably the first interglacial, or Aftonian, and that, further, he has shown that those species have not been found to have existed after that stage.

If we extend now our investigations into Florida we shall find some interesting facts.

At Arcadia many years ago about 25 species of vertebrate fossils were obtained. These consist of 15 mammals, an alligator, turtles, sea fishes, and sharks. The principal mammals are a megalonyx, *Chlamytherium septentrionale*, two species of *Glyptodon*, two horses, a tapir, a mastodon, and two elephants, one of which is *Elephas imperator*. Here we have many of the same genera and some of the same species as we have found in the four localities we have examined west of the

[3] Journ. Geol. 29: 505–514.

Mississippi River. *Chlamytherium* we have not mentioned in any collection until now, but it is found in Texas associated with other early Pleistocene fossils.

A second locality furnishing similar fossils is near Vero, St. Lucie County. From a deposit about 2 feet thick have been described about 30 species of mammals besides birds and reptiles. Among the mammals are *Chlamytherium*, three species of horses, two tapirs, a camel, a bison, the mastodon, the giant capybara (*Neochœrus*), a large tiger, and the floridan saber-tooth, *Smilodon*. In a sandstone of quite certainly the same geological age the skull of *Elephas imperator* was collected.

At Melbourne, Brevard County, Dr. J. W. Gidley and Dr. F. B. Loomis collected many vertebrate remains, among them *Elephas imperator*, three species of horses, one or more camels, *Chlamytherium*, and *Glyptodon*. It is wholly improbable that if these species existed during the middle and late stages of the Pleistocene, they had become so degenerate that they could not occupy the regions that I have mentioned.

The writer believes, therefore, that he is justified in maintaining that the deposits and their fossils found in the localities named and in other places in Florida and in Texas belong in the first interglacial stage. If there are yet those who believe otherwise it seems to be incumbent on them to present their reasons therefor.

PALEONTOLOGY.—*A new species of bear from the Pleistocene of Florida.* JAMES W. GIDLEY,[1] U. S. National Museum.

Two excellent papers recently published, one by Merriam and Stock[2], the other by Kraglievich[3], have done much to lessen the confusion which for many years has existed regarding the proper classification and relationship of the Arctotheres of the Western Hemisphere. Merriam and Stock placed the group under a subfamily of the Ursidae, Tremarctinae, to include the living genus *Tremarctos*, *Arctotherium*, and, doubtfully, *Arctodus*. They recognized five described species from the Pleistocene of North America, and

[1] Published by permission of the Secretary of the Smithsonian Institution. Received August 13, 1928.

[2] *Relationship and structure of the short-faced bear*, Arctotherium. Contr. Paleont., Carnegie Institution of Washington, **347**: 1–33, 10 plates, 1925.

[3] *Los Arctoterios Norteamericanos*. Ann. Museo Nac. Hist. Nat., **34**: 1–16, 1 plate, 1 text fig., 1926.

placed them, with the exception of *Arctodus pristinus*, in the genus *Arctotherium*, which is based on a South American Pleistocene species, *A. latidens*. These authors recognized the nearer approximation of *A. haplodon* Cope (Port Kennedy Cave) to the living *Tremarctos* as compared with the western species.

In his valuable work cited above, Lucas Kraglievich has pointed out the generic differences between *Arctotherium latidens* and other South American species and the North American species referred to that group, proposing a new genus, *Tremarctotherium*, to include the species *yukonense* Lambe, *simum* Cope, *californicum* Merriam, and doubtfully *haplodon* Cope. This arrangement, satisfactory in other respects, still leaves in doubt the status of *Arctodus* Leidy,[4] the first-named genus of this group. As is generally known, the genotype, *A. pristinus*, was based on a single lower second molar from Pleistocene deposits of the Ashley River at Ashley Ferry, South Carolina. The type has apparently been lost and by some this has seemed sufficient reason for discarding both the species and genus as indeterminate. Since, however, the excellent figures and description given by Leidy are sufficiently clear and the characters shown are such that its place in the Arctothere group can be established without much question, the name should be retained regardless of what disposition is made of *Tremarctos* and the other genera of the group.

Several specimens from the Pleistocene deposits at Melbourne, Florida, representing a new species here described, evidently belong to the *Arctodus* group and furnish additonal reasons for reestablishing the genus.

A critical comparison of Leidy's figures and description of the type specimen with the corresponding tooth in Cope's type of *Arctotherium* (*"Ursus"*) *haplodon* seems to leave little doubt regarding the close relationship of these species. Their size and general proportions are identical, the only difference of importance being the slightly greater width of the talonid portion of the tooth in *A. haplodon*, a difference which seems not of more than specific significance and may come within the range of individual variation.

The new species from Florida is in many ways intermediate between *Arctodus* and the living *Tremarctos*, but certain features seem to exclude it as well as *A. haplodon*, and, by inference, also, *A. pristinus* from the South American genus. *Arctodus* then, as now recognized, comprises the following species: *pristinus* Leidy, *haplodon* Cope, and

[4] Proc. Acad. Nat. Sci. Phila., 7: 90, 1854; LEIDY in HOLMES, *Post-Pleistocene of South Carolina*, p. 115, *pl. 23, figs. 3, 4*, 1860.

floridanus Gidley. It may be distinguished from *Arctotherium* by the greater relative length of the molars; the relatively greater expansion of the heel, or posterior expansion of upper m^2; and the relatively broader, flatter, and finer tuberculated area in the upper molars included between the continuous protocone-hypocone ridge and the bases of the main two outer cusps forming the paracone-metacone ridge. *Arctodus* may be distinguished from *Tremarctos* by its distinctly longer relative space occupied by the premolars, indicating a longer muzzled species; the relatively deeper proportions of the jaw; and the distinctly higher position of the point on the anterior border of the coronoid process where it is met by the anterior end of the ridge which divides the masseteric fossa and the antemasseteric pit.[5]

There are doubtless other and perhaps better generic characters that may be observed when the species comprising the genus are better known.

In March, 1926,[6] Peterson described some fine material of a bear which he referred to "*Arctotherium haplodon* (Cope)," with which it agrees very closely in size. However, if the figures may be relied on for comparison, it seems to belong rather definitely to the western genus *Tremarctotherium* Kraglievich, as is decided by the very narrow talon of m^2 and the apparent absence of the finely tuberculated areas of the molar in general.

Arctodus floridanus, new species

Type: Parts of skull and jaws with dentition represented by upper I^3; all the canines; left lower pm_4; left lower $m_{1 \& 3}$, right lower m_2; upper $m^{1 \& 2}$ of both sides; and alveoli of the left upper incisors and left pms 2 & 3. (Catalogue number 11,833, U. S. National Museum.)

Paratypes: Teeth from the same locality and horizon as the type (Catalogue Nos. 11,473, 11,474, 11,475, U. S. National Museum) and an upper m^2 from Florida, exact locality not known (No. 11,476).

Type locality and horizon: Country Club golf course, 2 miles west of Melbourne, Florida. Lower stratum of "No. 2 bed" of Sellards; Pleistocene.

Diagnosis: Size intermediate between the large *Arctodus haplodon* Cope and the living South American bear *Tremarctos ornatus* Gervais. Molars relatively long as in *T. ornatus;* relatively long diastema between lower premolars 2 and 3 and a somewhat shorter one between p_3 and p_4. Lower jaw relatively deep, depth at m_1, including this tooth, as great as the combined length of the molar series; antemasseteric fossa relatively deeper and larger than in *T. ornatus.*

Arctodus floridanus is distinguished from *A. pristinus* and *A. haplodon* by

[5] This name is proposed to avoid the use of the customary misnomer, "double masseteric fossa."

[6] *The fossils of the Frankstown cave, Bliss County, Pennsylvania.* Ann. Carnegie Mus., 16: (no. 2) 286-292, *pls. 24, 25.* 1926.

its smaller size and relatively narrower molars as well as by a tendency to greater numbers of the minute tubercles of the flat triturating surfaces of the molars.

COMPARATIVE MEASUREMENTS

	Arctodus floridanus Gidley Type	*Arctodus haplodon* Cope Cast of type	*Tremarctos ornatus* Gervais No. 210324 Dept. Biol. U. S. N. M.
	mm.	mm.	mm.
Upper dentition			
Length[7] of I^3 (base of crown)	10.3	.....	7.7
Width of I^3	9.3	.....	8.0
Length of canine (base of crown)	22.2	.....	18.3
Width of canine	14.6	.....	11.5
Length of m^1	19.7	.....	17.5
Greatest width of m^1 (posterior half)	15.7	.....	14.2
Length of m^2	31.0	.....	25.5
Greatest width of m^2 (anterior half)	16.6	.....	14.2
Lower dentition			
Length of canine (base of crown)	22.5	30.5	17.0
Width of canine	14.5	16.6	11.0
Length of p_4	9.0	11.0 (est.)	8.0
Width of p_4	5.6	.....	5.5
Length of m_1	22.3	28.0	20.0
Width of trigonid m_1	9.5	12.5	8.5
Width of talonid m_1	11.5	15.0	10.0
Length of m_2	22.0	25.6	20.0
Width of trigonid m_2	14.2	18.1	12.0
Width of talonid m_2	14.2	19.0	12.0
Length of m_3	18.2	21.2	14.5
Width of m_3	13.8	16.3	12.0
Length of dental series (canine to m_3)	133.7	164.0 (est.)	103.5
Depth of jaw at and including m_1	65.0	75.0	49.0
Diastema between p_2 and p_3	11.3	9.0	none
Diastema between p_3 and p_4	5.5	7.5	none

[7] Length = antero-posterior diameter. Width = transverse diameter.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

ENTOMOLOGICAL SOCIETY

397TH MEETING

The 397th regular meeting was held December 1, 1927, in Room 43 of the National Museum. Vice-president J. E. Graf presided.

Program: DR. S. B. FRACKER: *Control activities on the pink bollworm in the Southwest.* This subject is of interest from two standpoints: (1) The insect is attacking a crop of enormous value, a leading agricultural resource of this country; (2) the apparent total eradication of the pink bollworm where it became established in the main cotton belt of eastern Texas and Louisiana was a noteworthy achievement. The present distribution of the insect

includes practically all the cotton-growing areas between the Pecos River in Texas and New Mexico on the east and Tucson, Arizona, on the west. Of these areas the Arizona and western New Mexico portions are now the subject of clean-up measures and attempted eradication. In the Rio Grande Valley, however, the United States is subject to continuous infestation from Mexico and the elimination of the pink bollworm from that section is not being attempted. Present operations include search for new infestations, sterilization of all cottonseed in the infested areas, compression and fumigation of all cotton lint produced before being moved to outside points, the maintenance of road stations to prevent tourists from transporting cotton bolls, and clean-up activities in the western part of the area to eradicate infestations if possible.

Discussed by MARLATT and HOWARD.

Dr. A. C. BAKER: *The campaign of eradication of the Mexican fruitworm* Anastrepha ludens. The speaker gave a brief summary of the origin of the work and its progress and growth to date, and indicated on a map the various areas of infestation and centers of control operations. Details illustrating the various ramifications of the work were brought out, especially the cooperation of citrus growers, Rotary clubs, Chambers of Commerce, press service, and prominent citizens in eradication campaigns. A résumé of inspection activities was also given.

Discussed by BISHOPP, CURRIE, MARLATT, and HOWARD.

President DAVID L. CRAWFORD of the University of Hawaii made a brief address, emphasizing his special interest in Dr. Baker's paper because of his own work several years ago on the same problem. He discussed some of his observations made in Hawaii on the pest and outlined the status of the parasite control work. He also gave a short account of the work and scope of the Entomological Society of Hawaii.

Dr. GEORGE SALT, of Bussey Institute, discussed recent observations on banana insects in the San Marcos region of Colombia, notably a bee, *Trigona amalthea* Oliv., and a beetle, *Colaspis hypochlore* Laf. He gave information regarding the life history, habits and control of *Colaspis hypochlore* Laf., which in recent years has been an important pest of bananas, especially in low and wet areas. Good results have been obtained by drainage when lack of rainfall permitted.

Mr. C. P. CLAUSEN referred briefly to some of his recent activities in India in connection with collection and study of parasites of the Japanese beetle *Popillia japonica* Newm. At Shillong, he was especially fortunate in having the best possible location in the entire country for handling the parasite work on a large scale.

Mr. S. S. CROSSMAN, of the Gypsy Moth Laboratory, Melrose Highlands, Massachusetts, gave an account of the conditions following the recent flood disaster in Vermont. He also gave a short résumé of the present status of the gypsy moth work in New England, including a review of the parasite situation since 1905. He emphasized the fact that the data thus far assembled in Europe, on parasites, especially the marked variations in species that predominate in certain sections, indicate that studies of this kind should be made over a considerable period of years in order to obtain best results.

The regular program was followed by the annual election of officers. Those elected for the year 1928 are as follows: *Honorary President*, E. A. SCHWARZ; *President*, S. A. ROHWER; *First Vice-president*, J. E. GRAF; *Second Vice-president*, A. C. BAKER; *Recording Secretary*, J. S. WADE; *Corresponding Secretary-Treasurer*, S. A. ROHWER; *Editor*, W. R. WALTON; *Executive Com-*

mittee, the officers and C. T. GREEN, A. N. CAUDELL, and T. E. SNYDER; Representing the Society as a Vice-president of the Washington Academy of Sciences, A. G. BÖVING.

398TH MEETING

The 398th regular meeting was held January 5, 1928, in Room 43 of the National Museum. President ROHWER presided. The annual reports of the Recording Secretary, the Editor, and the Corresponding Secretary-Treasurer were read and approved, and the latter referred to an auditing committee.

The President reported the recent death of a member of the society, Mr. Jacob Kotinsky. T. E. SNYDER and A. N. CAUDELL were appointed to draw up suitable resolutions for presentation at the next meeting, for the records of the society, and for the bereaved family.

Program: R. C. SHANNON: *Experiences in the Argentine.* The speaker gave a brief general survey of the Argentine, its location, physical contour, agriculture, imports, exports, character of inhabitants, social customs, etc. Then he outlined his itinerary and summarized his entomological observations, especially his work on various species of mosquitoes, notably *Anopheles pseudopunctipennis* Theobald and related species, concerning which much detail was given. Maps of the region were shown and locations of more important studies and observation points were indicated. Mr. Shannon hopes at some future date to give a paper covering trips to Patagonia, the Bolivian border, and the Cataracts of Iguazu. Mr. Shannon adds the following: "I would like to state that my references to the life zones of Argentina, about which there was some controversy, were very brief remarks abstracted and summed up from a paper which I presented at the Argentine Entomological Society and which has probably been printed by this time in the Anales de la Sociedad Entomologica Argentina. This paper is entitled 'Contribution to the Study of the Life Zones of Argentina.' The different regions which I indicated in my talk are primarily based upon the physiographic and climatic features, coupled with the presence or absence of forests. In most of these areas, I found species of insects which appear to be peculiar to them; no doubt many occur, and it is, in general, evident that they represent natural areas so far as fauna and flora are concerned. In view of the above, it would be better to call these regions 'physiographic zones.' I feel sure, however, that these different zones will be found to coincide closely with the life zones which would be proposed by the ecologist."

Discussed by HYSLOP, ALDRICH, SNYDER, BISHOPP, and ROHWER.

Dr. F. C. CRAIGHEAD: *Forest insects.* A brief summary of major investigations of several of the more destructive species of tree-killing bark beetles of the genus *Dendroctonus* was given. By means of maps, blackboard diagrams, lantern slides and specimen report forms, the various areas of greatest infestation were located, the character and extent and methods of estimating injury were described, and control operations were reviewed. Some noteworthy details were brought out, such as the recent use of airplanes in estimating losses by forest tree insects, and the relation of "blue stain" fungus to insect injury in various sections of the country.

Discussed by ALDRICH, HYSLOP, ST. GEORGE, WALTON, CURRIE, and MCINDOO.

Dr. B. A. PORTER of Vincennes, Indiana, a non-resident member, made a few remarks. He stated that he especially enjoyed the meeting because there was no mention of codling moth or of poison residues.

399TH MEETING

The 399th regular meeting was held February 2, 1928, in Room 43 of the National Museum. President S. A. ROHWER presided.

Program: J. A. HYSLOP: *Our most important insects* (address of the retiring president). The speaker commented on the present tendency in economic entomology to follow the line of least resistance. From a vote cast by the working entomologists of the country as to the relative importance of the several insect pests throughout the United States, it would appear that the ten most important insects, in their order of importance, are: Codling moth, cutworm, San José scale, bollworm, grasshopper, plum curculio, boll weevil, Hessian fly, potato leafhopper, and white grub. The insects were then taken up in detail and a careful analysis made of the actual damage done by each, as near as can be ascertained. From this analysis the author concluded that the ten most important insects in the United States, in their order of importance, are: Mosquito, boll weevil, bollworm, spruce budworm, potato leafhopper, Hessian fly, grasshopper, cattle grub, cutworm, and chinch bug. The next ten insects in importance are: Potato beetle, cattle fly (other than grub), termite, corn root worm, alfalfa weevil, plum curculio, codling moth, apple aphid, army worm, and bark beetle. The granary pests would rank seventh in this list if taken as a group. (*Author's abstract.*)

Discussed by ROHWER, HOWARD, MORRISON, LARRIMER, GRAF, BISHOPP, SNYDER, MANN, SASSCER, and BURGESS.

CURTIS P. CLAUSEN: *Entomology in Japan.* An account of the development of entomological science in Japan from the time of its inception, approximately fifty years ago, to the present time was given, and the leading entomologists of the present day were mentioned. An account was given of the lines of investigation being conducted by the various laboratories under the Department of Agriculture and Commerce, the Imperial Universities, the Plant Quarantine Service, the provinces and the private institutions. The principal economic problems were discussed and compared with those of other oriental countries and of the United States. (*Author's abstract.*)

Discussed by BURGESS, HOWARD, and HYSLOP.

Dr. LOREN B. SMITH, of the Japanese Beetle Laboratory in New Jersey, spoke briefly about his work. He emphasized the extreme difficulty of making really satisfactory estimates of injury by Japanese beetle because of the many factors to be considered, especially the varying value of injured trees—some being worth only sale value of the wood therein, whereas others, located on fine estates, possess a high valuation for aesthetic reasons. He also reviewed briefly investigations during the past summer on the digestive system of the Japanese beetle in relation to the toxic effects of various chemicals, and effects on insects of what may possibly prove to be variations of radiant energy from various portions of the spectrum.

J. S. WADE, *Recording Secretary.*

SCIENTIFIC NOTES AND NEWS

WM. D. JOHNSTON, JR., has been appointed assistant geologist and RALPH M. LEGGETTE junior geologist in the Water-Resources Branch of the U. S. Geological Survey.

FRANCIS G. WELLS has been appointed junior engineer in the same branch of the Survey.